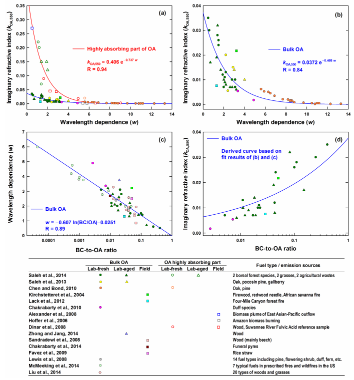
Light Absorption of Primary Organic Aerosol Paper Named ACS Editors' Choice

Research Highlight

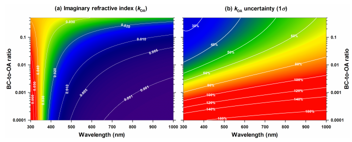
Organic aerosols (OAs) in the atmosphere affect Earth's energy budget by not only scattering but also absorbing solar radiation due to the presence of the so-called "brown carbon" (BrC) component. However, the absorptivities of OAs are not represented or are poorly represented in current climate and chemical transport models. Most models still treat primary OA (POA) as non-absorbing and underestimate the total warming effect of carbonaceous aerosols. Better parameterization of the light-absorbing properties of POA is urgently needed in models.

In this study, we provide a method to constrain the BrC absorptivity at the emission inventory level using recent laboratory and field observations. Since BrC is a complex mixture encompassing a large group of organic compounds with various absorptivities and lacking a formal analytical definition, we focus on the light-absorbing properties of the bulk POA instead of treating the BrC separately as a POA subset. We review currently available measurements of the light-absorbing POA, and quantify the wavelength-dependent imaginary refractive indices (kOA, the fundamental optical parameter determining the particle's absorptivity) and their uncertainties for the bulk POA emitted from biomass/biofuel, lignite, propane, and oil combustion sources. In particular, we parametrize the kOA of biomass/biofuel combustion sources as a function of the black carbon (BC)-to-OA ratio, indicating that the absorptive properties of POA depend strongly on burning conditions. The derived fuel-type-based kOA profiles are incorporated into a global carbonaceous aerosol emission inventory, and the integrated kOA values of sectoral and total POA emissions are presented. We also show how the POA radiative effect changes when accounting for the POA absorption.

The absorptive properties of POA from biomass/biofuel combustion sources depend strongly on burning conditions (e.g., black carbon (BC)-to-OA ratio). kOA at 550 nm of the bulk OA increases, whereas the wavelength dependence decreases with the BC-to-OA ratio, despite the differences in biomass/biofuel types, laboratory/field experiments, or fresh/aged aerosols. Although only fixed kOA profiles are given for POA generated from fossil-fuel combustion, due to the lack of data, we hypothesize that they also depend on the combustion condition similar to the biofuel/biomass case. We apply the fuel-type-based parameterization of kOA to a global carbonaceous aerosol emission inventory in the year 2010 and estimate the light absorption properties of POA emissions, as well as their radiative effects. Results of a simple radiative transfer model show that the POA absorptivity warms the atmosphere significantly and leads to #27% reduction in the amount of the net global average POA cooling compared to results from the nonabsorbing assumption. In sum, this study provides methods and datasets to address the BrC issue at the emission inventory level. When light-absorbing properties are incorporated into emissions, more realistic simulations of POA will be possible and will help us to better understand the climate impacts of POA emissions.



(a, b) Imaginary refractive index of OA at 550 nm (kOA,550) as a function of its wavelength dependence (w) for biomass burning and biofuel combustion sources, and (c) w and (d) kOA,550 as a function of the BC-to-OA ratio.



Estimated (a) imaginary refractive index of OA (kOA) and (b) its propagated uncertainty (1#) as a function of wavelength and BC-to-OA ratio for biomass burning and biofuel combustion sources.

Reference(s)

Lu Z, DG Streets, E Winijkul, F Yan, Y Chen, TC Bond, Y Feng, MK Dubey, S Liu, JP Pinto, and GR Carmichael. 2015. "Light absorption properties and radiative effects of primary organic aerosol emissions." Environmental Science & Technology, , doi:10.1021/acs.est.5b00211.

Contributors

Zifeng Lu, *Argonne National Laboratory*; David . Streets, *Argonne National Laboratory*

Working Group(s)

Aerosol Life Cycle